Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

A co-creation approach to identifying vehicle-sharing concepts for future markets

Benjamin Walter[a], David Storer[b], Albert Albers[a], Cristina Barberi[b]

[a]Karlsruhe Institute of Technology (KIT), IPEK – Instiute of Product Engineering, Kaiserstraße 10, 76131 Karlsruhe, Germany
[b]CRF SCpA, Strada Torino 50, 10043 Orbassano (TO), Italy

Abstract

While 'the sharing economy' is widely promoted as one of the most promising solutions to changing lifestyles in the field of mobility, huge uncertainty still exists regarding which future vehicle-sharing concepts should be developed to meet the very wide range of specific, individual needs. To reduce this uncertainty, new approaches are established and evaluated to integrate the perspective of different customer groups into the innovation process directly and continuously. One very promising approach in this context is 'co-creation'.
This paper presents both the methodology and the results of its application, developed in the co-creation project "ProVIL – product development with future users in a virtual idea laboratory" conducted in 2017 with a group of Mechanical Engineering Master's students focusing on the development of vehicle-sharing concepts for future users. To ensure relevance and quality of their concepts, the students used a wide range of existing and new innovation procedures, which were evaluated during the project in the sense of empirical Live-Lab studies.

Keywords: Innovation, co-creation, product development, students, Live-Lab, sharing economy, mobility

1. Introduction

Today around the globe mobility and transportation face a faster and more profound paradigm shift than ever before as a direct consequence of the various mega-trends including urbanisation, increasing motorization and need for mobility in countries like China and India, demographic shifts and an aging population and the ever-increasing political and social pressure to reduce emissions and noise from vehicles. Together these influencing factors force mobility and transportation worldwide to change dramatically from preparing international and national mobility strategies for the future, to the development of suitable new vehicle concepts to meet the evolving demands of society.

In addition to the increasingly stringent legislative requirements and restrictions, one of the most important influencing factors is the change in lifestyle and the needs of future users. As today's children and teenagers grow up with ubiquitous Wi-Fi and smartphones constantly in their hands, they see the conventional, privately-owned car not necessarily as a convenient mode of transport and status symbol, as perhaps their parents do, but rather as possibility to stay connected. Nevertheless the young of today are also the principal users of tomorrow's mobility and transportation systems – and so the providers of mobility solutions, are effectively obliged to listen and respond to their demands. Correspondingly, one of the primary issues is to convert this information into technically feasible and economically viable solutions, which also address other challenges such as the need to reduce emissions, noise and congestion.

A promising approach to achieve the necessary integration of different perspectives into product development projects is 'co-creation' which takes into account the opinion of potential future customers within the development process. Since there are currently relatively few examples of co-creation applied in practice, the Horizon2020 European project 'Science2Society' (GA 693651), which focuses on open innovation and science 2.0, investigates such an approach. Besides the co-creation approach presented in this contribution, Science2Society is dedicated to generate and validate further innovation approaches (co-location, collaborative R&D&I projects, intersectoral mobility, collaboration through Big Data and science 2.0, direct university coaching, online knowledge marketplaces) which function as university-industry-society interfacing schemes that have the potential to boost innovation potential in Europe. To reach this goal, Sciency2Society aims at the transferability of the investigated innovation schemes in order to enable other organisations (universities, companies and research transfer organisations) to use them for their own purposes.

2. Mobility concepts in sharing economies

The 'sharing economy' is widely promoted as one of the most promising solutions to changing lifestyles and the different issues to be addressed. Correspondingly, in the field of mobility and transportation, one of the most interesting concepts pursued around the world is that of vehicle-sharing and 'mobility-as-a-service'. However considerable uncertainty still exists regarding which future vehicle-sharing concepts should be developed to meet the very wide range of specific, individual needs while also enabling vehicle producers and future mobility service providers to remain profitable.

Furthermore worldwide, but particularly in Europe, China, the US and other OECD countries, the automotive industry is facing a paradigm shift: The next decade will witness a rapid and unprecedented transformation of mobility and transportation thanks to electrification, digitalization including connectivity and automation, in addition to the growth of vehicle-sharing and mobility-as-a-service. At the same time, software development is increasingly playing a key role in products and their development and manufacturing; together with the huge increases in computing power, which will be available in the next few years, the result will be much shorter innovation cycles, particularly in the Automotive Industry. This transformation will effectively force companies, providing the next generation solutions for mobility and transport, to revolutionize not only their products but also the way they do business in order to survive in the highly competitive global marketplace.

The international race is on to capture the new opportunities which are arising - and the difference between winning and losing will have a potentially dramatic and wide-reaching effect in terms of economics and employment. China in particular invests heavily in next generation mobility and transportation solutions - the result is that China already progresses at a very high rate with the development and deployment of highly innovative technological solutions also in the area of shared mobility.

The European Automotive Industry cannot afford to lose this race. Correspondingly, individual vehicle manufacturers must ensure that the products they launch over the coming years are not only highly innovative and affordable, but adequately satisfying the changing demands of customers while remaining profitable in order to enable economic growth and safeguard jobs. This is a particularly difficult challenge with respect to the shift towards vehicle-sharing and mobility-as-a-service.

Correspondingly three fundamentally important questions must be addressed urgently:

- How will the wishes and needs of future users be satisfied through shared mobility?
- What type of vehicles should be conceived for this?
- Which business models for mobility-as-a-service will prove to be successful in the future?

The purpose of this article is to contribute to answering these questions by describing a co-creation methodology that allows companies to involve potential future customers in development projects more closely.

3. Introducing innovation into the product development process

3.1. Co-creation in product development

The deliberate integration of specific customer requirements into the development process has increased in recent years and can meanwhile be regarded as standard. Various approaches, regarding the integration of user-centered design, are available to be implemented, such as lead-user innovation and usability testing (Sanders and Stappers 2008). These concepts are suitable to identify customer requirements prior to the actual development process or to test the result of the development process (a prototype, a product or a service), while the actual finding of a solution is entirely reserved for the engineers. A continuation of these approaches can be considered co-creation, which consists of companies and (future) customers working together to develop the product or service or at least in parts together (D. F. G. Network 2017). In extreme cases, this can even lead to customers being involved in the design of the product itself, which is known as co-construction.
In this way, the customer becomes an explicit part of the value chain and is no longer just a consumer and thus the target of value creation, but also one of the producers (Prahalad and Ramaswamy 2002). This has a great influence on the self-image of the people involved and requires a different way of dealing with each other on the one hand, but also, as a result, other competencies on the side of the company. For example, it is important to understand the lack of specialist knowledge of customers not as a weakness, but as a possible starting point for creativity (Kristensson et al. 2008). Because: Co-creation requires openness, mutual appreciation and the ability of professional moderation, as otherwise voluntary participation in a co-creation project by the client, whose most important basis is intrinsic motivation, is at risk.

3.2. Live-Labs

A Live-Lab in the context of product development is a research environment that enables the investigation of design methods, processes and tools in the most realistic way possible and to control the boundary conditions of the research to a high degree at the same time. The aim is to further develop and evaluate development methods, process elements, tools and innovation procedures in order to be able to provide added value to the practice in industrial companies.
Within the framework of Live-Labs, suitable test persons, such as students of technical studies from advanced semesters, work on real development tasks from an industrial company in a joint development project. In order to produce work results, they use various development methods such as creativity methods and evaluation methods as well as tools, e.g. software tools as part of a structured product development process. Through appropriate forms of data collection (observation, questioning, measurement and evaluation of work results, etc.), important insights can be gained within the framework of accompanying studies into the development methods and tools used, but also into procedural, social and personal aspects. In addition, if a larger number of test persons are involved in the Live-Lab, comparative studies with control groups are possible, which can ensure a better transferability of the results into the product development of industrial companies.
In contrast to pure laboratory environments, in which test persons work on tasks under strictly controlled boundary conditions, the success of the project is in the foreground for the test persons when working in a Live-Lab. The test persons perceive themselves less as test persons and more as real product developers, which means that their behavior is very realistic. Consequently, the test persons are more critical of immature methods and processes and use them consistently, especially when they are beneficial to the success of the project. This ensures that the results of the tests are significantly more relevant to practice than in laboratory environments. The Live-Lab concept can thus be classified between laboratory studies and field studies. Live-Labs contribute to resolving the conflicting goals between too specific and too generic research results. In contrast to the findings from pure laboratory studies and those from field studies in companies, the transferability of the findings to real-life application situations from Live-Labs is better.

The results from field studies are usually very company-specific and therefore have a very limited scope, whereas findings from pure laboratory environments are too general to be used directly in industrial companies. (Walter et al. 2016a)

4. The co-creation methodology 'ProVIL'

4.1. ProVIL – Product development in a Virtual Idea Laboratory

ProVIL – Product development in a Virtual Idea Laboratory is a co-creation product development project, which was designed at the Karlsruhe Institute of Technology (KIT). ProVIL is offered to Mechanical Engineering Master's students as a practical course (Albers et al. 2016). Within ProVIL, students work in independent teams with six persons each on a common, usually very broad, product development challenge, which is provided by a yearly changing industrial partner company. Besides the Mechanical Engineering students, students from Industrial Engineering and International Management from the Hochschule Karlsruhe Technik und Wirtschaft, University of Applies Sciences, accompany the course as innovation coaches, who support the students' groups with technical, social and organizational knowhow (Hahn 2016).
During the project the students follow a co-creation methodology consisting of a four-phase innovation process, a variety of innovation methods and procedures as well as modern software tools. ProVIL takes place every summer semester for about 3 months and is designed to serve up to around 80 to 100 students. The central hub for the coordination of all project stakeholders (students, project partner and university supervisors) is an innovation platform, which contains for example a representation of the innovation process, teaching videos regarding innovation methods, all kinds of templates and teaching material as well as team specific sections to upload (intermediate) project results. The innovation platform enables all participants to work and collaborate online and thus, is a key element for close and international co-creation (Walter et al. 2016b).
As the partner company usually is very interested in having the intellectual property, which is generated in ProVIL exclusively, the whole project is protected by a non-disclosure agreement as well as with a project contract which regulates all intellectual property issues with all stakeholders. From the project partner's perspective, ProVIL serves as a time-limited, external and highly creative innovation environment which can be located within the early stages of pre-development allowing for mostly explorative, but tangible technical solutions for future customers. Key success factors for excellent project results are the high level of creativity, open-mindedness and commitment of the students, a high level of commitment, interest and trust of the project partner and a professional and highly adaptive co-creation methodology as well as intense mentoring from the university. In this regard, ProVIL follows the principles of ASD – Agile Systems Design, a comprehensive innovation methodology developed at the IPEK – Institute of Product Engineering at the KIT (Albers et al. 2017).

4.2. The innovation process of ProVIL

The innovation process of ProVIL consists of four phases. In all phases, students carry out a variety of activities for which they use different innovation methods and tools (see Fig. 1). Each phase is completed with a milestone meeting (on-site or via web conference). At each milestone, all teams present their results to the project partner. Here, they receive feedback and can discuss open questions. In addition, the regular milestones mean that students feel valued by the project partner, which is an important element of their motivation.
The main goal of the analysis phase is to build up an extensive project knowledge base. For this purpose, the students conduct extensive research in pre-defined research fields. For example, they analyze existing markets, products and technologies, but also the competitive situation, global trends and successful business models. In addition, they develop future scenarios that consistently reflect possible situations in the future and can thus serve as a starting point for the development of corresponding products.
In the foresight phase, the main focus of ProVIL is on identifying market potential. The students thus examine the needs of customers in different market segments using qualitative (interviews) and quantitative (online surveys) methods. In addition, they observe customers when using existing products and derive opportunities for improvement from this. The constructive use of creativity methods supports the students in working out a multitude of product profiles, which describe market potentials in condensed and standardized form.
After selecting a product profile for each team during the second milestone meeting, the students work out suitable technical solutions in the conception phase, which they evaluate according to various criteria. In order to present their product ideas convincingly, the students also develop product videos, which describe the needs of customers as well as the mode of operation and use of their technical solution in a comprehensible way for all stakeholders.

In addition, during this phase, the students evaluate the range of variation of their product in terms of product generation engineering and develop a first physical or virtual prototype in order to evaluate critical functions as well as to obtain customer feedback in the following phase.

ProVIL Innovation process (phases and milestones)	**Project kickoff** → **1. milestone** → **2. milestone** → **3. milestone** → **Final presentation** **1. Analysis** *ca. 2 weeks*	**2. Foresight** *ca. 3 weeks*	**3. Conception** *ca. 4 weeks*	**4. Specification** *ca. 3 weeks*
Main objective	**Build up project knowledge base**	**Identify market potentials**	**Find technical solutions**	**Specify technical solutions**
Main activities	• Get to know all stakeholders and innovation plattform • Conduct research (market, technology) • Analyse existing product generations • Generate future scenarios • Share research results with all other teams	• Get to know your customer (conduct interviews ans surveys) • Understand Value propositions of possible products • Generate a variety of product profiles	• Find alternative technical solutions for your product • Define appropriate product structure and working principles • Build the first physical or virtual prototype	• Include possible customers in product validation • Build next development generation (prototype or mockup) • Prepare final presentation
Applied innovation methods and tools	• Persona method • Scenario technique • Online milestone	• Interviews • Online surveys • Lecture hall surveys • Creativity Methods • Community evaluation	• Creativity Methods • Product videos (Videoscribing) • „Chinese Wall“ • Intermediate pitch • Evaluation of variation shares of product • Sounding Board • Online milestone	• Virtual prototypes / mockups (Balsamiq) • Rapid Prototyping • Classification of product attributes • Dry Run of presentation • Professional booths

Fig 1: ProVIL innovation process, main objectives, main activities and applied innovation methods and tools

In the specification phase, the focus is on the in-depth elaboration of the next generation of the prototype, the inclusion of customer feedback and preparation for the final event, which consists of a presentation to several hundred people and an exhibition. At the exhibition, students present their products in use.

4.3. Methods and procedures to support innovation capabilities

In order to support the various activities in the four project phases in the best possible way, a number of methods, process elements and tools were used (see Fig. 1). Some of these are already known from agile innovation projects. The following is a selection of rather unknown and new procedures that support the co-creation approach in particular.

4.3.1. Scenario Technique: Projecting possible future situations to identify possible starting points for innovation

Starting point: Products that are yet to be developed do not have to address today's needs, but the needs of the future for which they are created. However, as this future is always unknown, i. e. different situations can arise, there are uncertainties regarding the best possible product design. However, even if different situations can occur, the attributes that describe them are usually consistent to a certain extent. For example, it is not to be expected that electric vehicles will prevail if, at the same time, the price of oil drops rapidly and there are no further restrictions.
Objective: The scenario technique aims to derive possible future situations, so-called scenarios, and to describe them in as much detail as possible. It makes no statements about the probability of scenarios occurring.
Description of procedure: The core of the Scenario Technique is the identification of key factors that have a decisive influence on future development, their projection into the future and the derivation of consistent scenarios. The Scenario Technique is a very comprehensive innovation method that requires an experienced expert and the appropriate special software. The version of the Scenario Technique used in ProVIL was adapted and scientifically evaluated especially for the application in the distributed product development.

4.3.2. Lecture hall survey tool: Including the opinion of many students to reconfirm product development focus.

Starting point: The early involvement of customers in the development process often fails because not enough customers are available at the right time. This is particularly true when customer wishes are to be quantitatively examined in order to be able to set priorities in development projects at an early stage. This innovation method uses the fact that ProVIL is held in parallel to a lecture on the fundamentals of product development with several hundred students. These can be integrated via a modern survey tool, which can be run on any common smartphone and is used regularly in the lecture.
Objective: The aim of the Lecture Hall survey tool is to sharpen the development focus of an innovation project at an early stage by involving a large, homogeneous group.
Description of procedure: With the help of the tool, a maximum of three to five questions can be asked, because otherwise the acceptance of the students and the lecturer who is responsible for the lecture decreases. A very good pre-selection of questions must therefore have already been made. In order to carry out the survey, the development team has to formulate the questions precisely and briefly explain the context of their development project in the lecture. Participation in the survey is voluntary for all students. The evaluation of the survey data is carried out according to the same criteria as in other customer surveys.

4.3.3. "Chinese Wall": Separating team members to ensure variety of solutions

Starting point: Agile product development has the potential to accelerate development projects through an organizational approach that relies on shorter work cycles. Overall, agile product development is increasingly and more frequently communicated in order to coordinate details at an early stage and continuously. Therefore, open project areas are often used. Besides the great advantages of such an approach, problems can also arise. In particular, frequent coordination with all team members can have a negative effect in some development phases, if the development of alternative solution concepts is omitted as a result. The reason for this is that permanent coordination can also lead to a team agreeing on the first solution that arises and that alternatives are not worked out to a degree of maturity on which they can actually be assessed. This means that the desired competition between solution concepts would be avoided. This problem can be further exacerbated if very dominant team members tend to overrule introverted team members at an early stage.
Objective: The aim of the "Chinese Wall" is used to systematically increase the variety of solutions used in the development of products.
Description of procedure: When using the "Chinese Wall", individual members or parts of a development team are specifically prohibited from communicating with each other, although this only applies to technical content. This ensures that the members or smaller sub teams do not influence each other in finding solutions, so that actually heterogeneous solutions are created. When using the "Chinese Wall", it is crucial that the timing and duration of the development work is tailored to the task at hand. In individual cases, the rough development directions or search fields for team members or sub teams can be defined if they are already known.

4.3.4. Sounding Board: Systematically include feedback into co-creation projects

Starting point: An important success factor in innovation projects is the involvement of feedback from future customers and other product developers. Appropriate meetings are often held for this purpose. The problem with these meetings is often that due to inefficient feedback processes, a large part of the potentially useful feedback is not expressed. Instead, such events tend to have repetitions of comments already made by feedback providers and to defend the development results presented by feedback recipients. In this way, the potential of corresponding feedback processes can only be exploited to a limited extent.
Objective: Increase the scope and quality of feedback from customers and product developers regarding the development results presented by systematically structuring feedback processes.
Description of procedure: As a starting point, a development result, e. g. a product idea or a product concept, is worked out as precisely as possible. For this purpose, a large poster with corresponding segments is usually suitable, in which product structure, functional structure, customer requirements, and other aspects are described and visualized. The sounding board starts with a short, concise presentation of the development results by the development team. Afterwards, all feedback givers have the opportunity to study the poster in peace and quiet. By means of colored adhesive dots with their initials, each participant indicated where they want to express criticism or point out ambiguities. Subsequently, a moderator will call up all points individually, whereupon the respective feedback provider has the possibility to express his comments concisely, while the development team notes the

feedback as basis for improvements. Any comments from the development team are only allowed if a comment is not understood. The defending of elements on the poster is not allowed and is prevented by the moderator.

5. Case Study

5.1. Overview

The case study investigated and described in this paper had two main goals. One the one hand, it should point out promising procedures for co-creation of industrial companies with future users of their products. On the other hand, it presents the students' results of a co-creation project in the field of "mobility solutions for future sharing economies" which took place in the summer semester 2017 with 48 Mechanical Engineering Master's students at the Karlsruhe Institute of Technology (KIT) and Centro Ricerche FCA (CRF).
During the project, weekly project surveys were carried out with the help of an online tool used by the students involved. Some of the questions were asked in each survey in order to keep track of developments over time, e.g. regarding the motivation of participants. Other questions were asked only once and related to processes, methods and tools used by students during the past project week. In this way, an extensive empirical data set was created. Qualitative evaluation methods were used, such as personal interviews and the evaluation of project results. The combination of qualitative and quantitative data means that comprehensive statements about the methods, processes and tools used can be derived.

5.2. Results

Within the framework of ProVIL, each team developed one solution for vehicle-sharing for future sharing economies. For each of the solutions, different product models such as CAD models, virtual mockups or physical prototypes were created. These were presented to a broad public at the closing event of ProVIL on 25 July 2017:

- Solution 1: A product which recognises dirt and lost items in car-sharing cars automatically
- Solution 2: A smartphone app which combines ride sharing with hitchhiking elements
- Solution 3: An adaptable business model for franchising in car-sharing markets
- Solution 4: A product which disinfects surfaces of the interior of sharing cars with radiation
- Solution 5: A robot-like solution which recharges electric cars in car parks automatically
- Solution 6: A solution which enables cyclists to transport groceries home comfortably
- Solution 7: A comfortable shopping cart for elderly people
- Solution 8: A solution which synchronizes personal settings of car-sharing customers across different cars and car types

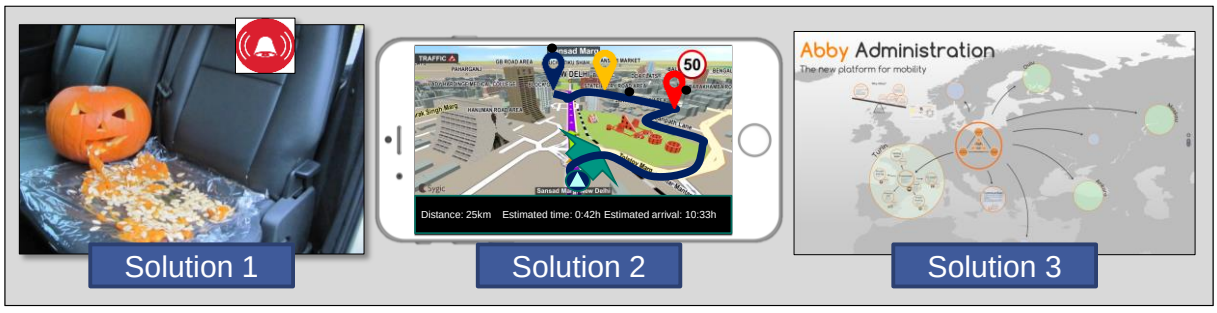

Fig. 2: Dirt recognition (solution 1), ride sharing with hitchhiking elements (solution 2), business model for franchising in car-sharing markets (solution 3)

Since the entire project is secured by a non-disclosure agreement for competitive reasons, a selection of three of the technical solutions are discussed here in more detail (see also Fig. 2).

5.2.1 Solution 1: A product which recognizes dirt and lost items in car-sharing cars automatically

One of the main concerns of today's car-sharing providers is to ensure the cleanliness of their vehicles on an ongoing basis. Two online surveys conducted in Germany and China during the course of the project revealed that a lack of cleanliness and hygiene is one of the main obstacles to becoming a car-sharing customer for many drivers who are currently not car-sharing customers. A further survey with a car-sharing operator revealed that this is

known, which is why the frequency of vehicle cleaning is partly increased. However, this also leads to an increase in the cleaning of vehicles that are actually clean, as the actual condition of the vehicle interior is unknown when a cleaning order is issued. Therefore, the need to design a product that reliably detects contamination in the vehicle interior and correctly classifies the cleanliness level of the vehicle was identified. It is crucial that the tracking of the vehicle interior takes place only after the customer's use of the vehicle, as this would otherwise be perceived by many users as an intrusion into the private sphere. However, this restriction is strongly dependent on cultural norms. The product, developed within the framework of ProVIL, relies on optical dirt detection, as this has both technological and economic advantages.

5.2.2 Solution 2: A smartphone app which combines ride sharing with hitchhiking elements

Another aspect of the sharing economy in mobility are the so-called ride sharing solutions, which all have in common that a car driver who drives a particular route takes a passenger who is usually unknown to him or her. Existing solutions (e. g. BlablaCar) have the problem that carpooling opportunities usually require a certain amount of planning. For example, an offered trip must be offered online and found and booked by a potential passenger. Changing the route or delays must be communicated individually, which further restricts the flexibility of existing solutions. Based on the analysis of existing solutions and customer requirements, the demand for a solution was derived that makes the use of ride sharing as simple, spontaneous and flexible as possible and is therefore suitable for both short and long distances. The solution developed in the project is designed as an additional function to existing navigation solutions. The matching of driver and passenger is largely automated and works live, taking into account the driver's current route, the current location and desired destination of the passenger as well as current traffic information. As soon as a meaningful "match" is found, the driver only has to confirm the request of the trip with one click. On request, every customer can choose to have other factors (social factors, common hobbies, etc.) taken into account during matchmaking.

5.2.3 Solution 3: An adaptable business model for franchising in car-sharing markets

An interesting fact in the context of car-sharing is that only about 10 percent of those who claim to be interested in using car-sharing are actually car-sharing customers. The main reason for this is that common car-sharing offers are usually highly standardized and therefore individual customer needs cannot be addressed. For example, it is not possible for customers to influence the location, vehicle type and equipment of car-sharing vehicles or even to integrate their own vehicle into an existing car-sharing fleet. From this, the need for a car-sharing model was derived, which envisages making the value proposition more flexible depending on local car-sharing markets. Since specific market know-how is required in individual cases to implement this flexibility, the corresponding concept was implemented as a franchise concept. This is a modular system and provides for the franchisee to activate the modules, which are meaningful for the local market, in order to address the needs of potential car-sharing customers in the best possible way.

5.3 Evaluation methodology and results

From the perspective of the Industrial partner involved in the activities, i.e. the research and innovation center of a large global vehicle manufacturer, the principal success factors of the specific application of ProVIL described in this paper can be considered to fall into two distinct categories:

- The first concerns the results of the activity and the information received which was facilitated by the direct interaction with the students - this helped to provide new points of view and specific opinions regarding the future mobility and transportation and the solutions which could be adopted in the future in this respect. Indeed, since the aim was to conduct co-creation by involving the students themselves as current and future users of mobility, the students were able to provide a new and potentially completely different perspective on the development of mobility solutions with respect to more experienced vehicle designers, a number of whom were also involved in the process to provide answers to the students, particularly for specific technical issues.
- The second concerns the development of the students involved – in particular the participation in the activities provided the students with the opportunity to gain first-hand experience of addressing a topic of significant relevance while developing and applying a series of ‘soft skills’ such as working in multi-disciplinary teams and articulating and presenting the results of the activities to a wider audience. Furthermore, the students also gained access to and experience of working with those colleagues involved in the process of generating new vehicle concepts and features.

One factor which must be taken into account relates to the difficulty of being able to come up with original ideas and concepts since today everyone is effectively bombarded with information and opinions. Furthermore the quality of the result naturally depends directly on the abilities, skills and level of interest and motivation of the participants. So it is of fundamental importance that throughout the process the mentors involved work to keep the levels of motivation and interest as high as possible by continually giving new assignments. The direct involvement also of key specialists and high level industrial representatives can also help to keep up motivation. In general it is essential to find an appropriate equilibrium between providing the participants with clear instructions and guidance on one hand, while encouraging and supporting free, inventive thinking on the other.

6. Conclusion and outlook

This article describes a co-creation approach that shows how a large number of Engineering Master's students can be directly involved in early stages of pre-development. As future customers of products to be developed, the students combine the customer's perspective with an engineering perspective, which is a highly interesting mix. In this respect, the students represent a great reservoir of creativity. However, this must be channeled through a comprehensive and sophisticated innovation methodology.
Through direct cooperation with the students in the project, the project partner's employees can also get to know new innovation methods and try them out directly. The innovation methodology outlined in this article takes into account in particular the fact that students and project partners are not in a common place. Further internationalization and new developments in the field of information and communication technology will probably lead to a significant increase in the relevance of the procedures used in ProVIL.
The solutions developed by the students within the framework of ProVIL can be described as very good from an innovation perspective. This is reflected in the fact that some of the development results are currently in the patenting process.
From a teaching perspective, ProVIL is a practical course that enables students to apply and thus gain deeper understanding of the processes, methods and tools of product development. In this respect, ProVIL is based on the didactic concept of case-based action learning, which makes learning content tangible on the basis of real challenges with real practical relevance.
From the perspective of design research, a number of new innovation methods are currently being developed in the areas of agile product development, early prototyping, customer integration and virtual validation. Since ProVIL has very well controllable boundary conditions, it serves - in addition to its character as an innovation project and course - as a Live-Lab for the continuous investigation of new or adapted processes, methods and tools in the field of innovation management.

Acknowledgements

This research was funded by the Horizon2020 European project 'Science2Society' (GA 693651).
The authors express gratitude to the students and all project members for their considerable effort and commitment.

References

Albers, A., Bursac, N., Walter, B., Hahn, C., Schröder, J., 2016. ProVIL – Produktentwicklung im virtuellen Ideenlabor. ENTWERFEN ENTWICKELN ERLEBEN 2016 (EEE 2016).

Albers, A., Bursac, N., Heimicke, J., Walter, B., Reiß, N., 2017. 20 years of co-creation using case based learning – An integrated approach for teaching innovation and research in Product Generation Engineering. Proceedings of the 20th International Conference on Interactive Collaborative Learning, 1014-1025.

D. F. G. Network, Design Factory Global Network. [Online] Available: http://dfgn.org/. Last Accessed on: Jun. 14 2017.

Hahn, C., Albers, A., Stöckner, M., Niever, M., Walter, B., Kerres, R., Bursac, N., 2017. Innovation Coaching in Foresight Processes for Distributed Product Development. CERC 2017. Paper accepted.

Kristensson, P., Matthing, J., Johansson, N., 2008. Key strategies for the successful involvement of customers in the co-creation of new technology-based services. International Journal of Service Industry Management, vol. 19, no. 4, 474–491.

Prahalad, C. K., Ramaswamy, V., 2004. Co-creation experiences: The next practice in value creation. Journal of Interactive Marketing, vol. 18, no. 3, 5–14.

Sanders, E. B.-N., Stappers, P. J., 2008. Co-creation and the new landscapes of design, CoDesign, vol. 4, no. 1, 5–18.

Walter, B., Albers, A., Haupt, F., Bursac, N., 2016a. Produktentwicklung im virtuellen Ideenlabor – Konzipierung und Implementierung eines Live-Lab. 27. DfX-Symposium 2016, 283-295.

Walter, B. Albers, A. Heck, M., Bursac, N. 2016b. ProVIL – Produktentwicklung im virtuellen Ideenlabor: Anpassung einer kollaborativen Innovationsplattform zur Nutzung eines communityorientierten Innovationsprozesses. Proceedings of 12. Symposium für Vorausschau und Technologieplanung, 197-209.